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ABSTRACT

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A PROJECT TO DEVELOP MODULES OF PHYSICS INSTRUCTION FOR FUTURE TECHNICIANS

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February 3, 1972

Abstract

Modules of physics instructional materials, each focusing on a particular physical system of interest to technical students, are being developed at four separate centers and coordinated by a Technical Physics Project Steering Committee. A typical module, constituting from one to three weeks of a physics course, will include a statement of behavioral objectives, entry/exit tests and a resource document for the instructor, as well as the instructional program. The latter will describe student investigations related to the system and lead the student to the understanding and skills necessary for him to meet the stated objectives. Although the main focus of each module will be on understanding how its physical system works, the intention is that a selected series of modules should introduce students to the major ideas and principles of physics central to their future role as technicians. The choice of systems and levels of treatment will be coordinated by the Steering Committee to provide adequate overlapping. Thus, instructors may vary their selection of modules to create courses which match local interests and degrees of sophistication. The project aims to produce forty to fifty modules over a four year period and to evaluate the use of these materials on a national scale.

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Background. The Technical Physics Project is an outgrowth of both a national need and a concern within the physics community. At a conference called by the American Association for the Advancement of Science in July, 1968,[1] attention was called to the rising demand for technicians in research and development laboratories throughout the United States. It was argued that the physics courses presently taught to future technicians at community colleges and technical institutes usually fail to motivate students, probably because they do not relate the important principles of physics to practical problems relevant to technology. The following year, the Commission on College Physics sponsored a national Conference on Technical Physics in the Two-Year Colleges, which was coordinated by Bill Aldridge, Florissant Valley Community College, and held at that St. Louis college on May 15-17, 1969.[2] While some contrasting views of the role of physics in technical curricula were expressed, the majority seemed to agree with the view expressed in the following excerpt from a U.S. Office of Education Report,[3] "...To be an effective, comprehending and perceptive worker with his professional counterpart,...the technician must be sufficiently grounded in the fundamental principles to permit some interpretation of the phenomena he encounters, to have a sound understanding of the theory as it is applied in the field, and to learn of technological changes in his specialty by independent study of reports of developments as they occur."

The St. Louis conferees agreed that an alternative was needed to the standard deductive-style, textbook-oriented program, but felt that no single course would be likely to satisfy the wide variability of technical programs and student backgrounds. Comments from the discussion sessions indicated that new materials were needed which should be highly flexible, so that they could meet a wide diversity of special needs. Such materials should cater to the technical student's initial interest in things rather than ideas, should deal with technological systems as units of learning, should reflect the fact that tests of student ability in two-year technology programs frequently show a lower verbal ability than quantitative ability, and should establish minimum behavioral or performance-oriented objectives for each learning unit, so that the student clearly knows what is expected of him.

In practical terms the outcome of the St. Louis conference was two-fold: (1) it provided a working definition of the type of learning units needed - self-contained "modules" of instructional materials, (2) it recommended that a national steering committee be formed to stimulate and coordinate the development of such modules.

Planning. In January 1970, the Esso Education Foundation awarded a small grant to the American Institute of Physics to support initial planning meetings of a Steering Committee under the Chairmanship of Nathaniel Frank, Massachusetts Institute of Technology, with staff support provided by the Director of AIP's Division of Education, Arnold Strassenburg. The Steering Committee chose a plan to establish several regional production centers rather than a central one for two reasons. First, many

[1] Technical Education--A Growing Challenge in American High Education, A Report by the Commission on Science Education of the American Association for the Advancement of Science, Washington, D.C., July 22-23, 1968.
[2] "Physics in Two-Year Technical Curricula," Bill G. Aldridge, The Physics Teacher, Vol. 8 No. 6, September 1970.
[3] USOE Report, "Criteria for Technical Education - A Suggested Guide," USOE Doc.80056 (November 1968).

educational institutions throughout the nation have technical programs geared to local needs, so it is highly desirable that project staff represent different geographical regions. Second, close collaboration of small groups at several sites should place less reliance on major summer efforts and allow creative efforts to be continued throughout the academic year.

During 1970, the Steering Committee met with potential directors of production centers. Development procedures were agreed upon and a general plan of attack formulated. Suitable module topics were identified, and the probable physics emphases they would contribute were listed in 17 broad categories. In this way a grid was spread across the major principles and topics central to physics for technicians, and the potential contribution of some 70 modules was analyzed to ensure a reasonably uniform distribution across this grid. It is anticipated that this overlap of topics, with a repetition of basic ideas in different circumstances, will give the student a repertoire of specifics, within the context of which generalizations can have a realistic impact. Overlapping modules will also vary in level of approach and thus, from the ultimate array of modules, instructors will be able to select a content and level of approach to suit their local needs.

Proposals. In January 1971 proposals were submitted to the National Science Foundation by seven institutions, which offered to act as production centers for Tech Physics Modules. Additionally a Steering Committee proposal, with AII as grantee, was submitted to support the coordinating and quality control activities of the Steering Committee. Early in June 1971 separate NSF grants were made to the following institutions:

Florissant Valley Community College, St. Louis
Director: Bill Aldridge
State University of New York at Binghamton
Co-Directors: Carl Stannard and Bruce Marsh
Technical Education Research Center, Cambridge, Massachusetts
Co-Directors: Nathaniel Frank and Ernest Klema
Oak Ridge Associated Universities, Oak Ridge, Tennessee
Director: Lawrence Akers

The grants turned some members of the original Steering Committee into production center Directors, resulting in a reconstruction of the Steering Committee as follows:

Murray Alexander, De Anza College, Cupertino, California
Chairman
Lewis Fibel, Virginia Polytechnical Institute, Blacksburg, Virginia
David Gavenda, University of Texas, Austin
Alan Holden, New Vernon, New Jersey
George Kesler, McDonnell Douglas Co., St. Louis
Theodore Pohrte, Future Resources & Development Inc., Westport, Connecticut
Charles Shoup, National Research Corp., Boston
Arnold Strassenburg, AIP, SUNY at Stony Brook, New York
Louis Wertman, New York City Community College

Preliminary Survey. Prior to summer 1971 production, a major effort was made to survey already existing materials which might be adaptable for use in the form proposed. A consultant was hired to assist in acquiring information on such materials from (1) industrial firms, (2) armed service training programs, (3) government laboratories, (4) scientific societies. About 70 industrial firms responded

with information and about 20 other communications were received. Relevant materials were distributed to the appropriate project directors. It is too early to determine how much of this material will find its way into the modules being developed.

Module Format. Each Tech Physics module will contain the following components:

(1) a statement of prerequisites;
(2) a set of behavioral objectives toward which the student will work;
(3) an entry test;
(4) an instructional program consisting of
    (a) a physical system to be available in the laboratory around which the module is built, and
    (b) a description of how the student will interact with the system in order to meet the objectives of (2). This will include narrative, questions, problems, aids, and activities involving experimentation. There will also be an emphasis on industrial applications of the principles developed;
(5) an exit test; and
(6) a resource document for the instructor, elaborating on the system, the physics, multi-media aids and industrial applications.

Among systems used in modules currently under development are an incandescent lamp, a transistor heat sink, an ion chamber, a Geiger-Mueller counter, a toaster, binoculars, a pressure cooker, an electro mechanical switch and a spectrophotometer. The current list of proposed modules numbers 50, and an important function of the Steering Committee will be to study the proposed module outlines and coordinate the pattern and level of physics topics extracted from the systems used.

Module Production. Each production center operates slightly differently. TERC operates the year around and works on several projects simultaneously, of which Tech Physics is one. Two scientists devote a major fraction of their time to Tech Physics and several others contribute in smaller ways. The modules planned by this group touch on all the major subfields of classical physics. Three modules are to be field tested during the spring 1972 semester at community colleges and technical institutes in the Boston area.

The SUNY project staff are drawn from five different campuses of the New York State University system. Five of the six scientists have full-time academic appointments, and thus can give complete attention to the Tech Physics Project only during the summer. The Department of Physics on the Binghamton campus of SUNY provides facilities and auxiliary staff. Every senior staff member has complete responsibility for a module. Most of the modules currently under development treat the physics of electromechanical devices. Plans call for first drafts to be ready for field testing at New York two-year colleges in the spring of 1972.

The Oak Ridge Tech Physics group is part of the Special Training Division of ORAU. This group is continuously active in preparing instructional materials and offering short courses for the training of teachers and technicians in the use of nuclear instrumentation. Two of the team of six scientists will devote major attention to module production. Since summer is a time of intensive activity for this group, involving short courses and training sessions, the major effort at module production did not begin until the fall of 1971. However, one or two modules using modern physics devices will be ready for field testing at community colleges in Tennessee by the spring of 1972.

Florissant Valley Community College has in house the competence and facilities to both produce and field test modules. A staff of six scientists work as a production-line team. Because the group is largely employed at FVCC, module production can continue, though at a reduced pace compared to summer efforts, throughout the academic year. Work on five modules covering topics in optics, electricity, and mechanics was initiated in the summer of 1971. Two of these were field tested at FVCC in the fall 1971 semester; others will be tested in the spring semester. Other nearby colleges are likely to cooperate in the field testing.

Subject to continuing grants it is anticipated that 40 to 50 modules will be produced over a 4-year period. Production is proceeding on schedule, but it is too early to be confident that all modules currently planned will meet the standards being set and prove acceptable in field testing.

Coordination. Thus far, the Steering Committee has exercised its coordination function in three ways: (1) by a series of individual visits to each production center to interact with staff at the planning and production stages; (2) by a series of meetings, some in conjunction with the Project Directors, at which policy decisions were made; (3) by written reviews of preliminary drafts. The first year is proving to be one of evolutionary progress for all concerned, and the flow of ideas between committee and production centers has been a two-way process. From this is emerging a working philosophy, and a refinement of the criteria by which the Steering Committee will judge the acceptability of individual modules for inclusion in the set to be published.

In broad terms, modules should capitalize on the student's interest in doing things that are related to the technology he plans to enter. Whenever possible a "need-to-know" should be established and related to his future work. Textual material should complement experiments, rather than the reverse. Visual presentation should play a large role in the mechanism of information transfer. Problems and questions should often relate to situations the student may encounter in his later work, and the interpreting of observations should be coupled to the interpreting of commercial data and specification sheets. While most modules will focus on some aspect of technology, the Steering Committee believes that the overall objective of any module should be to uncover the physics involved and not to develop the technology of the device. It is expected that the predominant type of module will be one in which physics principles are learned by studying the operation of the chosen system itself. In some cases, however, a complex system may be analyzed by studying, with conventional equipment, how components of the device operate, and returning to examine the operation of the system as a whole. There may also be a very few modules, selected for special reasons, in which some important physical principles are studied by focusing on a filmed system rather than on a laboratory one.

Course Construction. A module is expected to require from one to three weeks of time in a typical one-year physics course. Thus, during the year, about 15 different modules could be completed, if little time were devoted to other kinds of instructional materials. The ultimate output of the project is projected to be about three times this amount. This redundancy is considered essential for flexibility in course design, a characteristic regarded as one of the major project goals. The project organizers believe that no monolithic text could accommodate the needs of physics courses in the many different technology curricula offered by two-year colleges serving their local industries, and the wide spectrum of backgrounds and abilities which the students bring to their study of technical physics.

Field Testing. During the development stage of a module, the experiments and preliminary draft of module sections are validated by student trial, and refined by project staff review. Each center has made arrangements with local two-year colleges or technical institutes to field test the module in an ongoing technical physics course. Where appropriate, prototypes of the device used in the module will be provided to the cooperating schools, and briefing sessions will be held for the instructors involved. The latter will administer tests, provide feedback to the center and gather data for evaluation of the module's effectiveness. Field tests of three modules have so far revealed no difficulty inserting them into otherwise traditional courses.

Motivation. What should be the primary goal of physics instruction in a technology curriculum? Some would advocate dealing primarily with theoretical aspects of basic physics, leaving applications to technology courses and on-the-job training. At the other extreme are those who favor limiting the physics course to practical applications of physics principles - and in their ranks are some who feel that physicists are ineffective in this task. The Tech Physics Project takes the intermediate position embodied in the following four points: (1) that the physics course should lead the student to understand basic principles of physics; (2) that the physics instructor is best able to do this; (3) that motivation is an all important factor in this, as in any, learning process, and (4) that technology students are more likely to be motivated by inductive discovery through personal investigation of a technological system than by a process of deductive reasoning which stems from abstract generalizations based on the experience of others.

Evaluation. From the St. Louis conference came a call for new materials in a flexible, modular format. The detailed objectives, content and emphases of the modules will gradually evolve from this project. The Steering Committee feels that a thorough evaluation of the project output will have to be made if the new approach is to be accepted and used on a national scale. To this end a comprehensive evaluation plan has been proposed. It would employ independent evaluation specialists to design instruments and procedures for establishing the validity of the module objectives in the context of technical curricula and for systematically investigating the effects of module use in comparison with the use of traditional materials.

Outlook. As module production increases and feedback from field testing becomes substantial, progress reports in the form of project newsletters will be issued. The Steering Committee is optimistic that, four years from now, there will be available in published form an array of Technical Physics Modules with varied topics, emphases, instructional styles and levels of difficulty. From this array, instructors will be able to assemble a variety of physics courses to match the interests and abilities of their technical students, and to serve the needs of local communities for trained technicians. It will not be surprising if some of these modules also prove stimulating to students in other two-year college programs.